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Small mammals from the Seasonally Dry Tropical Forests of the Huallaga river basin and new records for San Martín department, Peru

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Abstract

The Seasonally Dry Tropical Forests in Peru are well known for their bird and plant diversity and endemicity, but little is known about the diversity of small mammals. We report the diversity of small volant and non-volant mammals from the Seasonally Dry Tropical Forests of the Huallaga river basin in the San Martín Department, working on both sides of the river, making a sampling effort of 3060 traps-night for non-volant and 104 mist nets-night for volant mammals. We recorded 29 species, including five marsupials, three rodents, and 21 bats. Among the bats, phyllostomids were the most diverse group with 16 species. Short-tailed Spiny-rat, *Proechimys brevicauda* (Günther, 1877) and Seba's Short-tailed Bat, *Carollia perspicillata* (Linnaeus, 1758), featured the highest relative abundance. In addition, we report the first records for the San Martín Department of *Peropteryx macrotis* (Wagner, 1843), *Saccopteryx bilineata* (Temminck, 1838), *Lonchorhina aurita* Tomes, 1863, *Vampyriscus bidens* (Dobson, 1878), and *Myotis simus* Thomas, 1901. The species richness and diversity indices indicate the study site has a high diversity value; however, fragmentation and rapid changes in land-use are the main threats faced by the biodiversity of these dry forests.

Keywords

Chiroptera, Didelphimorphia, fragmentation, Neotropics, Rodentia

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Introduction

Seasonally Dry Tropical Forests (SDTF) are characterized by pronounced seasonality, annual rainfall less than 1600 mm, receiving about 80% of the rains during the wet season, resulting in several drought months during the dry season, which can last five or six months (Pennington et al. 2000; Murphy and Lugo 1995; Maass and Burgos 2011). These forests have a smaller stature and smaller basal areas than humid tropical forests (Pennington et al. 2000; Murphy and Lugo 1995). They range from Mexico to northern Argentina and southeastern Brazil, representing 22% of the forested area of South America (Murphy and Lugo 1986; Olson et al. 2001); but having a fragmented distribution with areas of different sizes (Espinosa et al. 2012).

SDTF are floristic and structurally more complex than the rainforests (Murphy and Lugo 1986), although

their species diversity is generally low (Diaz-Pulido et al. 2014). These forests are unique ecosystems, with part of the fauna associated with these forests presenting morphological, physiological, and behavioral adaptations to the availability of resources between seasons (Särkinen et al. 2011; Diaz-Pulido et al. 2014). Therefore, even though SDTF have low diversity, they have endemic species (Ceballos 1995). SDTF have been considered very fragile ecosystems, threatened by changes in land use and human population growth (Janzen 1988; Maass et al. 1995).

Peruvian SDTF occur on the western and eastern slopes of the Andes and are divided into three subunits: Equatorial (Tumbes, Piura, Lambayeque, and isolated remnants in La Libertad), inter-Andean (valleys of Huancabamba, Marañón, Apurímac, and Mantaro, and in some valleys of Cusco and Puno), and Oriental (surroundings of Tarapoto in San Martín) (Linares-Palomino 2004b). Most of these forests range from sea level to 1000 m elevation, but the Mantaro Valley and Apurímac Valley reach up to 2350 m and 2400 m, respectively (Linares-Palomino 2004b; Aguirre et al. 2006; Linares-Palomino and Pennington 2007).

The diversity of plants (e.g., Linares-Palomino 2006) and birds (e.g., Vásquez-Arevalo et al. 2018; Saldaña et al. 2020) are well studied in these forests, but little is known about the diversity of small mammals. Neighboring countries such as Colombia and Ecuador have a better record of mammal species associated with SDTF (Tirira 2001; Boada and Roman 2005; Calonge et al. 2010; Diaz-Pulido et al. 2014). In Peru, two studies have surveyed small areas of dry forests in Tumbes (Pacheco et al. 2007a) and Apurímac (Pacheco et al. 2007b). As yet, no survey has been conducted in the dry forest of San Martín department, the most isolated Peruvian dry forest (Linares-Palomino 2004b). This lack of information is of great concern because San Martín is one of the most deforested departments in Peru (MINAM 2020). Previous extensive studies in this department are scarce and had been carried out mostly in the Río Abiseo National Park (Leo and Romo 1992; Gardner and Romo 1993; Leo and Gardner 1993) and the Mayo river basin (Velazco and Patterson 2019), which are located in montane and humid lowland forests, respectively.

Our study evaluates the diversity, relative abundance, and species richness of small mammals in the SDTF of the Huallaga river basin, San Martín Department. We discuss the conservation status of the species and the forests and update the species richness present in San Martín department.

Study Area

The SDTF of the Huallaga river basin are within San Martín department in the provinces of Bellavista, Picota, and San Martín. The climate is seasonal, with the wet season between October and March and the dry season between April to September; the average temperature is 26 °C, and the annual rainfall is 1164.4 mm (García-Villacorta 2009). Dispersed scrub dominates the vegetation as "Quinilla" (*Manilkara bidentata* (A.DC.) A.Chev.), "Capirona" (*Calycophyllum spruceanum* (Benth.) K.Schum.), and "Machinga" (*Brosimum alicastrum* Sw.). The soils are predominantly black, with large and small stones scattered on the ground (García-Villacorta 2009). Agricultural areas are extensive, with large-scale plantings of rice and cacao, and notably fragment the dry forest into isolated remnants of various sizes. We surveyed during the dry season, between 22 August and 11 September 2015, in four private conservation areas (Fig. 1). These areas are protected patches of forest surrounded by extensive agricultural areas:

El Valle del Biavo (VB): Bellavista Province, Bajo Biavo District (07°09′S, 076°36′W, 520 m elevation), located at the right bank of the Huallaga river. It has a low canopy with trees 5–10 m tall. The relief is undulating, with slopes reaching 75° in some areas. There are no permanent water sources and only small shallow, dispersed pools.

El Incaico (EI): Bellavista Province, Alto Biavo District (07°18′S, 076°22′W, 800 m elevation), located at the right bank of the Huallaga river. The canopy is about 15–20 m high. The relief has moderate or steep slopes, up to 75°. The soil is mainly silty, and there are no permanent water sources.

El Quinillal (EQ): between Bajo Biavo (Bellavista Province) and Tingo de Ponasa (Picota Province) Districts (07°02′S, 076°17′W, 420 m elevation), located on the right bank of the Huallaga river. The canopy is approximately 10–20 m high. The slopes are moderate, the soil is silty clay, and there are no permanent water sources.

Ojos de Agua (OA): Picota Province, Pucacaca District (06°49′S, 076°26′W, 500 m elevation), located on the left bank of the Huallaga river. The canopy is 15–30 m high. The relief is moderate, with slopes of up to 50°, and generally clay soil. There are permanent ponds and a small, 0.5–1 m wide creek.

Methods

Sampling and identification.

Non-volants. The survey was carried out on 14 nights: three nights each in VB, EI, and EQ, and five nights in OA (Table 1). We used Victor Mouse Traps installed on the ground in four transects, each with 30 stations (two snap-traps per station). The adjacent stations were 10 m apart. We placed the snap-traps close to tree trunks or bushes and marked them with flagging tape indicating the transect code and trap number. They were baited in the afternoon with a mixture of oatmeal, peanut butter, and vanilla or banana essences, and sometimes with chopped raisins. We checked the snap-traps in the morning between 6:30 and 7:30 h.

Volants. The survey was carried out on 13 nights: three nights in VB, two in EI, and four each in EQ and

Figure 1. Study area showing the sampling localities in the Seasonally Dry Tropical Forests of the Huallaga river basin, San Martín Department (in black), Peru. Sampling localities (white circles) are also shown in the inset map of Peru.

Table 1. Sampling effort by locality employed in this study from the SDTF of the Huallaga river basin, San Martín

Localities	Traps-night (TN)			Mist nets-night (MN)		
	Sampling nights	No. of transects	Sampling effort	Sampling nights	No. of mist nets	Sampling effort
Valle del Biavo	3	4	720	3	8	24
El Incaico	3	4	720	2	8	16
El Quinillal	3	4	720	4	8	32
Ojos de agua	5	3	900	4	8	32
Total	14	15	3060	13	32	104

OA (Table 1). We installed eight mist nets (12 m wide and 2.5 m high) in the understory and checked them every 30 minutes from 18:00 to 00:00 h. The mist nets were placed individually, or as two nets spliced together, in various places depending on the terrain. The distance between mist nets was at least 20 m. Mist nets were placed near the undergrowth and on the footpaths and four of them near small bodies of water in OA.

We took the standard biometric measurements, including total length (TL), tail length (T), hindfoot length (F), and ear length (E). We also measured the tragus length (Tr) and forearm length (FA) for bats. Sex and reproductive condition were also recorded. We euthanized collected specimens following the ethical guidelines of the American Society of Mammalogy (Sikes et al. 2016). We released juvenile, pregnant, and lactating individuals. We deposited all collected specimens at the Museo de Historia Natural of the Universidad Nacional Mayor de San Marcos (MUSM). We also added unpublished data from specimens in the Mammal Collection of the MUSM.

Specimens were then identified in laboratory using external, cranial, and dental characteristics following specialized bibliography for rodents (Patton et al. 2000; Voss et al. 2001; Bonvicino and Weksler 2015; Patton et al. 2015), marsupials (Gardner 2008; Lima Silva et al. 2019), and bats (Goodwin and Greenhall 1961; Hall 1981; Lassieur and Wilson 1989; Yancey et al. 1998; Yee 2000; Gardner 2008; Moratelli 2012; Ruelas and Pacheco 2015; Díaz et al. 2016; Ruelas 2017; Morales-Martínez and López-Arévalo 2018), and by side-by-side comparisons with specimens in the MUSM collection. We followed the taxonomic nomenclature of Pacheco et al. (2009), Patton et al. (2015), and recent changes by Voss et al. (2018, 2019) and Lima Silva et al. (2019). The taxonomic order follows Pacheco et al. (2009). Using digital

calipers, we measured the condylobasal length (CBL), nasal length (NL), nasal breadth (NB), least interorbital breadth (LIB), least postorbital breadth (LPB), zygomatic breadth (ZB), palatal length (PL), palatal breadth (PB), maxillary toothrow length (MTR), length of upper molar series (LM), length from first to third upper molar (M1–M3), and width of third upper molar (WM3) for marsupials following Voss et al. (2019). Similarly, we measured the greatest skull length (GSL), braincase width (BC), braincase height (BH), condyle-incisive length (CIL), condyle-canine length (CCL), palatal length (PL), palatal width (PW), mastoid width (MW), rostrum width (RW), postorbital constriction (POC), zygomatic width (ZW), maxillary toothrow length (MTL), canine width (CW), foramen magnum width (FMW), mandibular length (ML), mandible height (MH), mandibular toothrow length (MaTL), and coronoid height (CH) for bats following Zurc and Velazco (2010).

Data analysis. We expressed the sampling effort as traps-night (TN) for non-volants and as mist nets-night (MN) for volants. We estimated the accumulation curve by the Clench model using the formula:

$$v_2 = (a \cdot v_1) / [1 + (b \cdot v_1)],$$

where "a" is the rate of increase of new species at the start of the sampling and "b" is the parameter related to the shape of the curve (Jimenez-Valverde and Hortal 2003) using Estimates v. 9, and Statistica v. 13 for graphics.

We determined the relative abundance for each species and sampling locality based on sampling effort (Caughley 1977) expressed as individuals per 100 traps-night (ind/TN) for non-volants and as individuals per 10 mist nets-night (ind/MN) for volants. We also obtained the relative abundance based on percentage for each species by dividing the captured specimens per species by 100 between the total recorded specimens. We estimated the diversity of SDTF of the Huallaga river basin by the Shannon-Wiener index (H′), Simpson dominance index (1−D), and reverse Simpson index (1/D) using the Vegan package (Oksanen 2015) in R v. 3.4.1 (R Core Team 2017).

Results

Accumulation curve. The accumulation curve for non-volant mammals, adjusted 99.13% to the Clench model, predicted 10 species (a/b = 9.96), three more than recorded (Fig. 2a). The accumulated curve for volant mammals, adjusted to 99.7%, predicted 27 species (a/b = 26.58), eight more than the number of captured bat species (Fig. 2b). Although the curves did not reach the asymptote, our samples represented 70% of the non-volant species estimated by the model and 70.4% of the volant species.

Species richness. Based on a sampling effort of 3060 TN for non-volant mammals and 104 MN for volant ones (Table 1), we recorded 29 species of small mammals (Appendix Table A1), which includes five didelphids: *Didelphis marsupialis* Linnaeus, 1758, *Marmosa constantiae* Thomas, 1904, *Marmosops bishopi* (Pine, 1981), *Marmosops noctivagus* (Tschudi, 1844), and *Philander canus* (Osgood, 1913); three rodents: *Hylaeamys perenensis* (Allen, 1901), *Nectomys apicalis* Peters, 1861, and *Proechimys brevicauda*; and 21 bats: *Peropteryx macrotis*, *Saccopteryx bilineata*, *Artibeus anderseni* Osgood, 1916, *Artibeus lituratus* (Olfers, 1818), *Artibeus obscurus* (Schinz, 1821), *Artibeus planirostris* (Spix, 1823), *Carollia benkeithi* Solari & Baker, 2006, *Carollia brevicauda* (Schinz, 1821), *Carollia perspicillata*, *Chiroderma villosum* Peters, 1860, *Desmodus rotundus* (Geoffroy, 1810), *Glossophaga soricina* (Pallas, 1766), *Lonchorhina aurita*, *Micronycteris megalotis* (Gray, 1842), *Platyrrhinus incarum* (Thomas, 1912), *Sturnira giannae* Velazco & Patterson, 2019, *Uroderma bilobatum* Peters, 1866, *Vampyriscus bidens*, *Pteronotus fuscus* (Allen, 1911), *Myotis keaysi* Allen, 1914, and *Myotis simus* (Figs. 3A–C, 4A–T; Tables 2, 3). Three of them were opportunistically recorded (incidental records) by observations or carcasses. *Didelphis marsupialis* was recorded based on skeletal remains of three individuals found in VB, EI, and OA; six individuals of *S. bilineata* were observed on the roof of the biological station of OA; and a lactating female, with her breeding, of *D. rotundus* were observed

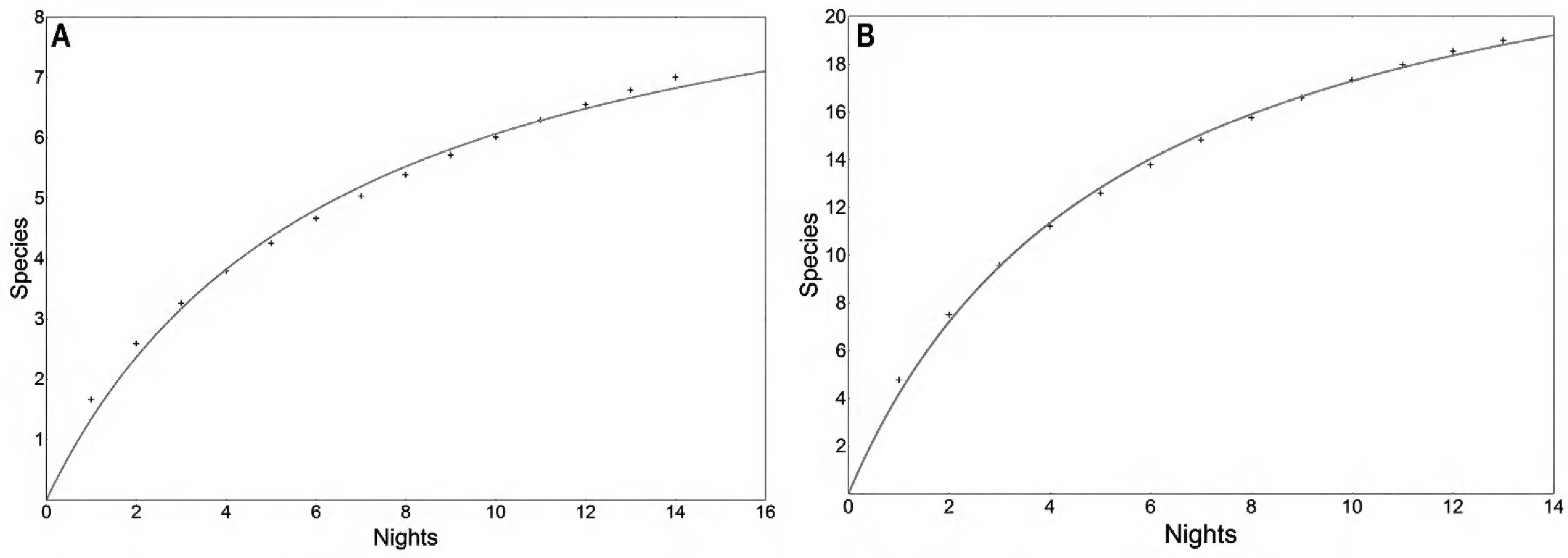

Figure 2. Species accumulation curve of small mammals from SDTF of the Huallaga river basin: **A.** Clench curve for non-volant mammals: $S_{obs} = 7$; a = 1.55, b = 0.16, $R^2 = 0.991$, a/b = 9.96; **B.** Clench curve for volant mammals: $S_{obs} = 19$; a = 4.96, b = 0.19, $R^2 = 0.997$, a/b = 26.58.

Figure 3. Non-volant mammals recorded at the Seasonally Dry Tropical Forests of the Huallaga river basin. **A.** *Marmosa constantiae*. **B.** *Philander canus*. **C.** *Proechimys brevicauda*.

Table 2. Sex, weight (in grams), and external and craniodental measurements (in millimeters) of *Peropteryx macrotis, Lonchorhina aurita, Vampyriscus bidens*, and *Myotis simus* from the SDTF of the Huallaga river basin, San Martín.

Measurements	*Peropteryx macrotis*	*Peropteryx macrotis*	*Peropteryx macrotis*	*Lonchorhina aurita*	*Vampyriscus bidens*	*Myotis simus*
	MUSM 43764	MUSM 43765	MUSM 43766	MUSM 43864	MUSM 43882	MUSM 43884
Sex	female	male	male	female	female	female
W	7.00	5.50	6.15	17.50	11.50	4.75
TL	66.00	62.00	57.00	129.00	51.00	80.00
T	20.00	15.00	14.00	62.00	0	32.00
F	10.00	7.50	9.50	13.00	12.00	6.00
E	18.00	18.00	17.50	35.00	19.00	14.00
Tr	7.00	5.00	5.50	19.00	6.00	7.00
FA	47.55	43.35	44.85	57.65	39.70	36.70
GSL	14.17	14.22	14.51	21.65	20.23	—
BW	6.87	6.61	6.91	10.32	8.91	—
BH	5.48	5.30	5.45	7.56	7.87	—
CIL	—	—	—	20.39	18.15	—
CCL	13.23	12.58	13.03	19.53	17.53	—
PL	—	—	—	10.60	9.64*	—
PW	1.73	1.91	1.72	2.84	2.40	—
MW	7.71	7.61	7.66	11.30	10.38	—
RW	3.87	3.72	4.00	4.85	5.25	—
POC	2.89	3.02	2.70	5.02	5.27	—
ZW	8.79	8.40	8.62	12.16	11.34	—
MTL	5.91	5.78	5.86	7.38	6.86	—
CW	2.91	2.83	2.85	3.26	3.23	—
FMW	3.16	3.17	3.03	4.83	4.33	—
ML	10.39	10.15	10.09	14.12	12.49	—
MH	1.44	1.53	1.32	1.95	2.02	—
MaTL	6.54	6.23	6.31	8.70	7.87	—
CH	2.53	2.45	2.42	4.09	4.47	—

in "Cueva de la Virgen" in Pucacaca, near to OA. We did not include these species in the diversity analyses.

The most notable species richness was recorded in OA (16 species) and the least in EI (10 species). Most of the species reported, mainly bats, are present at both banks of the Huallaga river. *Marmosops noctivagus*, *N. apicalis*, *P. macrotis*, and *A. planirostris* were recorded only on the left bank of the Huallaga river. While *M. constantiae, P. canus, C. villosum*, *L. aurita*, *M. megalotis*, *P. incarum*, *S. giannae*, *V. bidens*, *M. keaysi*, and *M. simus* were recorded only on the right bank of Huallaga River (Tables 2, 3).

We present the first records to the San Martín department of five bat species as follow:

Class Mammalia
Order Chiroptera
Family Emballonuridae

***Peropteryx macrotis* (Wagner, 1843)**
Figure 4A

Material examined. PERU • Ojos de Agua private conservation area, Picota Province; 06°50′47″S, 076°21′02″W; 341 m elevation; 11.IX.2015; D. Ruelas leg.; mist nets; 1 ♀ (MUSM 43764) and 2 ♂ (MUSM 43765, 43766); all adults.

Identification. The following combination of morphological characters allows us to recognize this species: elongated and naked rostrum and chin, dorsal fur brown or reddish, ventral fur lighter in color; ears not

Figure 4. Volant mammals recorded at the Seasonally Dry Tropical Forests of the Huallaga river basin. **A.** *Peropteryx macrotis*. **B.** *Saccopteryx bilineata*. **C.** *Artibeus anderseni*. **D.** *Artibeus lituratus*. **E.** *Artibeus obscurus*. **F.** *Artibeus planirostris*. **G.** *Carollia benkeithi*. **H.** *Carollia brevicauda*. **I.** *Carollia perspicillata*. **J.** *Chiroderma villosum*. **K.** *Glossophaga soricina*. **L.** *Micronycteris megalotis*. **M**. *Lonchorhina aurita*. **N.** *Platyrrhinus incarum*. **O.** *Sturnira giannae*. **P.** *Uroderma bilobatum*. **Q.** *Vampyriscus bidens*. **R.** *Pteronotus fuscus*. **S.** *Myotis keaysi*. **T.** *Myotis simus*.

Table 3. Sex, age, weight (in grams), and external and craniodental measurements (in millimeters) of *Marmosa constantiae* from the SDTF of the Huallaga river basin, San Martín. Age class follows Voss et al. (2001).

Measurements	MUSM 43888	MUSM 43889	MUSM 43890	MUSM 43891
Sex	Female	Male	Female	Male
Age	Adult	Adult	Adult	Adult
W	68.00	61.00	61.00	110.00
TL	374.00	362.00	350.00	376.00
T	222.00	205.00	212.00	216.00
F	25.00	25.00	24.00	25.00
E	25.00	23.00	25.00	—
CBL	39.47	38.60	38.59	42.56
NL	18.37	17.35	17.20	19.29
NB	5.32	5.78	5.02	6.83
LIB	7.05	6.84	6.64	7.55
LPB	6.98	7.42	7.18	7.74
ZB	22.79	22.13	20.94	23.58
PL	22.17	22.01	21.91	23.96
PB	12.54	12.48	12.31	13.45
MTR	16.22	16.25	16.63	17.53
LM	8.25	8.47	8.78	8.64
M1-M3	6.89	7.12	7.45	7.08
WM3	2.53	2.88	2.85	2.98

interconnected; wings terminate at an attachment point on each ankle; glandular wing sac on the upper edge of the antebrachial membrane, and unattached ears; tail almost one-third of the length of body and perforating the uropatagium; small skull with a sharp angle between an inflated rostrum and braincase; postorbital process long, slender; basisphenoid pit undivided; upper and lower incisors short and simple, lower incisors trifid; first upper premolar broad, not filiform, with an accessory cusp; dental formula 1/3, 1/1, 2/2, 3/3 = 32. External and craniodental measurements are in Table 2. Morphological characters and measurements are within the variation range for the species following Goodwin and Greenhall (1961), Yee (2000), and MUSM collection specimens (Ucayali Department: MUSM 44151–44154).

Remarks. This species is known to Mexico, Grenada, Central America, Colombia, Venezuela, Trinidad and Tobago, the Guianas, Ecuador, Peru, Brazil, Bolivia, and Paraguay (Hood and Gardner 2008). In Peru, *P. macrotis* occurs in the Selva Baja and Sabana de Palmera ecoregions (Pacheco et al. 2009). This record is the first for the San Martín Department; it is 430 km north of the nearest record, at San Juan, Pasco department (Tuttle 1970; Hood and Gardner 2008).

Saccopteryx bilineata (Temminck, 1838)

Figure 4B

Material examined. PERU • Ojos de Agua private conservation area, Picota Province; 06°49′S, 076°26′W; 500 m elevation; D. Ruelas obs.; 6 individuals observed on the roof of the biological station.

Identification. This species differs from other bats in having two whitish longitudinal wavy stripes on the dorsum. Besides, the individuals had the underparts brownish; the muzzle was simple, pointed, and without a leaf-like excrescence; the uropatagium was thinly haired to the exertion of the tail; and the tail perforated the upper surface of the uropatagium. These morphological characters agree with those described by Hall (1981), Yancey et al. (1998), and Díaz et al. (2016).

Remarks. This species occurs from Colombia, Trinidad, and the Guianas to Bolivia and Brazil (Hood and Gardner 2008). In Peru, *S. bilineata* occurs in the Bosque Pluvial del Pacífico, Selva Baja, and Sabana de Palmera ecoregions (Pacheco et al. 2009). The new record in the eastern Andes of Peru extends the range of *S. bilineata* 430 km north from the nearest presious record at San Juan, Pasco department (Tuttle 1970; Hood and Gardner 2008).

Lonchorhina aurita Tomes, 1863

Figure 4M

Material examined. PERU • El Quinillal private conservation area, Bellavista Province; 07°04′15″S, 076°23′59″W; 316 m elevation; 01.IX.2015; D. Ruelas leg.; mist nets; 1 ♀ (MUSM 43864) and another specimen accidentally released.

Identification. These morphological characters allow us to recognize this species: dorsal fur uniformly reddish-brown with the underparts slightly paler; ears broad, bluntly pointed, and as long as the head; tragus more than one-half the length of the ear and notched at the base; lance-shaped nose leaf with a prominent longitudinal ridge; lance tapers to a sharp point with the entire nose leaf nearly equal in length to the ears; five fleshy protuberances collectively hide the opening to the nostrils; upper lip covered with small, fleshy warts, which hang over the bottom lip; lower lip with an inverted triangular space flanked laterally by elongate, smooth pads; tail longer than the femur, and reaches to the posterior tip of the uropatagium; wings extend to the distal end of the tibia; foot shorter than calcar. Skull elongated with rostrum narrow; nasal arched, curved, and overhang the

nasal opening; palatine with large projection; first premolar tiny; second premolar higher than molars; massive molars; broad mesopterygoid fossa; dental formula: 2/2 1/1 2/3 3/3 = 34. External and craniodental measurements are shown in Table 2. These morphological characters and measurements are within the variation range for the species following Lassieur and Wilson (1989), Díaz et al. (2016), Morales-Martínez and López-Arévalo (2018), and with specimens of the MUSM collection (Cusco Department: MUSM 19702, 19702; Madre de Dios Department: MUSM 19704).

Remarks. This species occurs from Central America, southern Mexico, The Bahamas, Colombia, Ecuador, Trinidad, eastern and northern Venezuela, eastern Peru, eastern Bolivia, and eastern Brazil (Williams and Genoways 2008). In Peru. *L. aurita* occurs in the Selva Baja ecoregion (Pacheco et al. 2009). We report this species for the first time in San Martín department, 410 km north from the nearest previous record at San Juan, Pasco Department (Tuttle 1970; Williams and Genoways 2008).

Additional records. Moyobamba, Caserio Selva Alegre (MUSM 47731); Rioja, Cueva de Palestina (de los Guácharos) (MUSM 50655).

***Vampyriscus bidens* (Dobson, 1878)**
Figure 4Q

Material examined. PERU • El Incaico private conservation area, Bellavista Province; 07°20′15″S, 076°25′14″W; 493 m elevation; 28.VIII.2015; D. Ruelas; mist nets; 1 ♀, MUSM 43882, adult.

Identification. We identified this species by the marked white supraorbital stripes; broad lateral lancet of the nose leaf; high and broad tip of the nose leaf; conspicuous dorsal line; wide uropatagium with a fringe of hairs; elongated skull; short rostrum; rectangular nasal opening; medium posteropalatal process; asymmetric and bilobed inner upper incisors; non-caniniform first lower premolar; a pair of lower incisors; high coronoid process; dental formula: 2/1 1/1 2/2 2/3 = 28. External and craniodental measurements are shown in Table 2. These characters and measurements are within the variation range for the species following Ruelas and Pacheco (2015) and Díaz et al. (2016).

Remarks. *Vampyriscus bidens* occurs from Colombia, Venezuela, Guyana, Suriname, French Guiana, Ecuador, Peru, Brazil, and Bolivia (Arroyo-Cabrales 2008). In Peru, *V. bidens* occurs in the Selva Baja ecoregion (Pacheco et al. 2009). The new record extends the geographic range of this species by 310 km south from the nearest previous record at Huampami, Amazonas Department (Patton et al. 1982; Arroyo-Cabrales 2008).

Familia Vespertilionidae

***Myotis simus* Thomas, 1901**
Figure 4T

Material examined. PERU • El Quinillal private conservation area, Bellavista Province; 07°04′15″S, 076°23′59″W; 316 m elevation; 01.IX. 2015; D. Ruelas leg.; mist nets; 1 ♀, MUSM 43884, adult.

Identification. The following combination of morphological characters distinguishes this species: relatively short conical face that lacks skin folds or appendages; relatively small eyes, small ears; thin and elongated tail fully embedded within the uropatagium reaching the free edge and longer than the hind legs; short ears, extending forward halfway from the eye to nostril; barely evident antitragal notch; pointed tragus, slightly curving outward above and convex below, with a small triangular lobule at the outer base; naked dorsally uropatagium without a fringe of hairs along the trailing edge; few scattered hairs on the basal portion of the uropatagium; calcar with a small keel; third upper premolar crowded to lingual side; sagittal and occipital crests present. These characters agree with those described by Moratelli (2012) and Díaz et al. (2016) and are in agreement with specimens in the MUSM collection (Ucayali Department: MUSM 24593, 30022, 40490, 44223). We present external measurements in Table 2.

Remarks. *Myotis simus* occurs from the Amazon basin of Colombia, Bolivia, Brazil, Ecuador, Peru, and farther south to Argentina and Paraguay (Wilson 2008). In Peru, *M. simus* ocurrs in the Yungas and Selva Baja ecoregions (Pacheco et al. 2009). The new record of extends this species' geographic range by 410 km northwest of the nearest previous record at Oxapampa, Pasco department (Wilson 2008).

Additional to these five species, we confirmed the presence of two rare species in San Martín department.

Order Didelphimorphia
Family Didelphidae

***Marmosa constantiae* (Thomas, 1904)**
Figure 3A

Material examined. PERU • Valle del Biavo private conservation area, Bellavista Province; 07°11′54″S, 076°33′38″W; 348 m elevation; 24–25.VIII.2015; D. Ruelas leg.; snap-trap; 1 ♀ (MUSM 43888, 43890) and 2 ♂ (MUSM 43889, 43891); all adults.

Identification. The following combination of morphological characters allows us to recognize this large mouse opossum: drab, woolly dorsal fur; not a well-defined facial mask; yellowish-buffy cheeks; light dorsal fur washed with orange on the body sides; yellowish-cream to yellowish buffy ventral fur; two-thirds of the distal portion in ventral view slightly depigmented; long, all-dark tail with rhomboidal scales arranged in spiral series; laterally and dorsally projected supraorbital ridges; developed postorbital processes, well-developed in most mature adults; almost completely ossified palates with short-narrow maxillopalatine openings; moderately convergent temporal ridges shaping a sagittal crest; and small auditory bullae. External and craniodental

measurements are given in Table 3. Morphological characters and measurements of our specimens are within the variation range for the species following Lima Silva et al. (2019) and Voss et al. (2019) and in specimens in the MUSM collection (Ucayali Department: MUSM 44233–44237, 44240–44243).

Remarks. Recently Lima Silva et al. (2019) and Voss et al. (2019) recognized *constantiae* as the valid name for specimens previously known as *demararae* in Peru. *Marmosa constantiae* has a wide distribution in southwestern Amazonia, including western Brazil, eastern Peru, and northern Bolivia (Lima Silva et al. 2019). In Peru, this species is distributed in the Yungas and Selva Baja ecoregions (Pacheco et al. 2009).

Order Rodentia
Family Cricetidae

***Nectomys apicalis* Peters, 1861**

Material examined. PERU • Ojos de Agua private conservation area, Picota Province; 06°50′41″S, 076°27′54″W; 383 m elevation; 07.IX.2015; D. Ruelas leg.; snap-trap; 1 ♀, MUSM 43909; juvenile.

Identification. Our specimen is juvenile (age class 1, following Voss 1991) and was recognized by the following combination of morphological characters: dorsal fur uniformly grayish brown; underparts pale neutral gray moderately washed; dark brown tail, pinnae entirely gray; hindfoot with five plantar pads and plantar surface squamate; narrow and deep posterolateral palatal pits; opisthodont incisors; interparietal deep relative to its width. Morphological characters of this specimen agree with those described by Bonvicino and Weksler (2015) and with specimens in the MUSM collection (Cusco Department: MUSM 9190–9192; Madre de Dios Department: MUSM 9211–9213). External measurements: TL: 250 mm, T: 130 mm, F: 36 mm, E: 21 mm. Weight: 50 g.

Remarks. *Nectomys apicalis* is widely distributed in eastern Ecuador, eastern Peru, and northwestern Brazil but considered rare (Bonvicino and Weksler 2015). These authors also suggest that *Nectomys apicalis* may represent a species complex that needs study. In Peru, it is distributed in the Selva Baja and Sabana de Palmera ecoregions (Pacheco et al. 2009). **Additional records.** Tarapoto, San Martín Province (MUSM 5062); Huicungo, Mariscal Cáceres Province (MUSM 24398).

Relative abundance and diversity.

Non-volants (Table 2). We recorded the highest relative abundance in VB (3.47 ind/TN). Among species, the short-tailed spiny-rat *Proechimys brevicauda* was the most abundant (4.41 ind/TN, 61.82%) and recorded in all localities, followed by *Hylaeamys perenensis* (1.47 ind/TN, 20.00%), which was recorded in three localities, except EQ. The least abundant species were *Marmosops noctivagus* (0.11 ind/TN), *Philander canus* (0.14 ind/TN), and *Nectomys apicalis* (0.11 ind/TN).

Volants (Table 3). The study site with the highest relative abundance was EQ (38.13 ind/MN), mainly due to the greater abundance of *Carollia perspicillata* (29.06 ind/MN), higher than in the other localities. Among species, *C. perspicillata* (51.04 ind/MN, 53.42%) and *Artibeus lituratus* (14.79 ind/MN, 15.41%) were the most abundant bats and recorded in all localities (Table 4). In contrast, *Micronycteris megalotis* (0.63 ind/MN), *Vampyriscus bidens* (0.63 ind/MN), *Myotis keaysi* (0.31 ind/MN), and *Myotis simus* (0.31 ind/MN) were the least abundance with only one individual each.

The Shannon-Wiener (H′ = 2.08), Simpson (1/D = 3.85), and the inverse of Simpson (1–D = 0.74) indexes showed moderate values of diversity.

Discussion

Diversity and abundance. We present the first report of small mammals from the SDTF of the Huallaga river basin. For five of these species, we provide the first records from San Martín department. Twenty-nine species of small mammals are now known from the SDTF of the Huallaga river basin, representing 22.1% of this San Martín department's small mammal species (131 species: Appendix Table A2). The cumulative curves suggest that more sampling effort is needed to obtain a more considerable species richness; therefore, we recommend continuing the diversity studies, increasing localities, and sampling effort.

We found that Chiroptera was the order with the greatest species richness (21 species), similar to other humid and dry forests (e.g., Tirira 2001; Boada and Román 2005; Pacheco et al. 2007b; Diaz-Pulido et al. 2014). Phyllostomidae was the family with the highest species richness. The number of nectarivorous species was low (only one species), probably related to incomplete sampling (Fig. 2). In effect, the insectivorous bats were better represented (*Peropteryx macrotis*, *Pteronotus fuscus*, *Micronycteris megalotis*, *Lonchorhina aurita*, *Myotis keaysi*, and *Myotis simus*) than bats from other

Table 4. Relative abundance (ind/TN) and percentages (%) of the non—volant small mammals by locality concerning the Huallaga River from the SDTF of the Huallaga river basin, on the right bank: Valle del Biavo (VB), El Incaico (EI), El Quinillal (EQ), and on the left bank: Ojos de agua (OA). * = Incidental record.

Species	Right bank			Left bank	%
	VB	EI	EQ	OA	
Order Didelphimorphia					
*Didelphis marsupialis**	—	—	—	—	—
Marmosa constantiae	0.56	—	—	—	7.27
Marmosops bishopi	—	0.28	—	0.11	5.45
Marmosops noctivagus	—	—	—	0.11	1.82
Philander canus	0.14	—	—	—	1.82
Order Rodentia					
Hylaeamys perenensis	0.56	0.69	—	0.22	20.00
Nectomys apicalis	—	—	—	0.11	1.82
Proechimys brevicauda	2.22	0.83	0.14	1.22	61.82
Total	3.47	1.81	0.14	1.78	100.00

Table 5. Relative abundance (ind/MN) and percentages (%) of the volant small mammals by locality concerning the Huallaga River from the SDTF of the Huallaga river basin, on the right bank: Valle del Biavo (VB), El Incaico (EI), El Quinillal (EQ), and on the left bank: Ojos de Agua (OA). * = Incidental record.

Species	Right bank			Left bank	%
	VB	EI	EQ	OA	
Peropteryx macrotis	—	—	—	0.94	1.03
*Saccopteryx bilineata**	—	—	—	—	—
Artibeus anderseni	3.33	—	0.63	2.50	6.16
Artibeus lituratus	0.42	1.25	2.50	10.63	15.41
Artibeus obscurus	—	0.63	—	0.31	0.68
Artibeus planirostris	—	—	—	3.13	3.42
Carollia benkeithi	5.83	—	0.94	0.63	6.51
Carollia brevicauda	—	—	1.88	0.63	2.74
Carollia perspicillata	5.42	1.88	29.06	14.69	53.42
Chiroderma villosum	1.25	—	—	—	1.03
*Desmodus rotundus**	—	—	—	—	—
Glossophaga soricina	0.83	—	—	0.31	1.03
Lonchorhina aurita	—	—	0.63	—	0.68
Micronycteris megalotis	—	0.63	—	—	0.34
Platyrrhinus incarum	—	1.88	—	—	0.68
Sturnira giannae	—		0.94	—	1.03
Uroderma bilobatum	—	1.25	0.63	1.88	3.42
Vampyriscus bidens	—	0.63	—	—	0.34
Pteronotus fuscus	—	—	0.31	0.63	1.03
Myotis keaysi	—	—	0.31	—	0.34
Myotis simus	—	—	0.31	—	0.34
Total	17.08	8.13	38.13	36.25	100.00

food guilds, especially in EI and EQ, where the sampling area was closer to inactive or abandoned farmland (D. Ruelas pers. obs.). Although insectivorous bats tend to fly high in and over the canopy (Fleming et al. 1972; Kalko et al. 1996; Bernard 2001), they were mist-netted in the understory. This is probably because the trees in SDTF are smaller than in the humid forests (Pennington 2000; Linares-Palomino 2004a). Frugivorous species were the most abundant, especially *Carollia* spp. and *Artibeus* spp., agreeing with other studies in forests with secondary growth, fragmented or disturbed habitats (e.g., Fleming 1991; Calonge et al. 2010; Mena 2010). These species have mainly a generalist diet, including insects, and a wide dispersion capacity (Fleming 1991; York and Billings 2009).

Among the non-volant species, we found Rodentia was more abundant than Didelphimorphia, mainly due to the abundance of *Proechimys brevicauda* (4.41 ind/TN, 61.82%). A similar pattern was reported along the La Novia River (Purús, Ucayali department), a locality in the Peruvian humid forest, where *Proechimys* species increased the relative abundance of rodents (Ruelas et al. 2016).

Mammalian composition in dry forests. The similarity in the species composition of the SDTF in the Huallaga river basin (SDTF-H), the Pacific Equatorial Dry Forest (PEDF), and the Seasonally Inter-Andean Dry Forest of Apurimac (SIDF-A) is low (Appendix Table A3). One species, *D. rotundus*, is shared among SDTF-H, PEDF, and SDIF-A; another species, *A. planirostris*, is shared between SDTF-H and SIDF-A, and six species, *Didelphis marsupialis*, *C. brevicauda*, *Carollia perspicillata*, *Glossophaga soricina*, *Micronycteris megalotis,* and *M. keaysi*, are shared between SDTF-H and PEDF. On the other hand, we noted that the PEDF have mammals from lowland humid forests, such as *C. perspicillata* or *M. megalotis*, probably because this forest is surrounded on its northern portion by the Pacific Tropical rainforests.

We found that the small mammals of the SDTF of the Huallaga river basin also occur in nearby lowland humid forests in the Selva Baja ecoregion (see Pacheco et al. 2009), but there are no endemic species of dry ecosystems. The lack of species endemic to dry ecosystems or adapted to low humidity conditions is probably due one or a combination of the following: (1) the sampling effort was low, (2) the dry forests are highly fragmented by anthropogenic causes, and (3) the eastern dry forests are historically young, with insufficient time for mammal species to evolve or adapt. From the eastern Peruvian dry forest, only the Marañón Dry Valley (MDV) contains a dry-ecosystem endemic species, *Platalina genovensium* Thomas, 1928 (Ruelas and Pacheco 2018), which is widely distributed on the western Andes. MDV also contains endemic species of other vertebrates (e.g., Koch 2014; Koch et al. 2015, 2018) and plants (e.g., Särkinen et al. 2011; Marcelo-Peña et al. 2016). Although these comparisons are preliminary, they suggest that eastern dry forests may not have a typical or endemic mammalian fauna. Instead, their biota is composed of fauna elements of nearby habitats.

Conservation. Currently, the main threats to the diversity of small mammals in San Martín are the fragmentation and loss of habitat due to changes in land use mainly to expand the agricultural frontier (Marquardt et al. 2019). Changes in land use in other Peruvian regions with forests generate changes in diversity, abundance, forest dynamics, and trophic structure (Mena 2010). The human demographic growth and changed of land use for agriculture in the SDTF date back to the 1960s when the Peruvian government promoted the occupation of the Amazonian forests and the construction of the Marginal de la Selva Highway, which completely crosses the Peruvian territory, to reduce the human population pressure on the highlands and to reduce the migration towards Metropolitan Lima (CVR 2004). These actions may have directly impacted the biodiversity of the Huallaga river basin by fragmenting the SDTF there, with human settlements and farmlands mainly in the lower basin, leaving isolated forest relicts in areas with high slopes, which are not suitable for large-scale cultivation. This may explain the current composition of the small mammals in the surveyed localities. Few studies have assessed the impact of fragmentation and deforestation on small mammals in Peru (e.g., Mena 2010; Noblecilla 2020). Unfortunately,

there are no complete studies on the diversity of San Martín to determine the rate of loss.

The lack of knowledge of the mammal diversity in this region is not due to geographical distance or difficulty of access, as in other Amazonian regions, as the Marginal de la Selva highway was built more than 50 years ago. We found that the lack of inventories is mainly due to the period of violence that occurred in Peru during the 1980s, which lasted approximately 20 years, and later the region remained dangerous by the increase of illegal cultivation of coca for drug trafficking and the associated narcoterrorism (CVR 2004). This complicated situation made the region relatively inaccessible to researchers, with few biological inventories as a result.

Although our inventory was carried out in the dry season, the information about small mammals in the SDTF of the Huallaga river basin is still valuable and an essential piece for the conservation of the biodiversity in this region. However, we recommend additional surveys in both seasons to assess changes in the diversity due to the seasonality, and to evaluate more localities on both sides of the Huallaga River to determine whether populations differ genetically. We also recommend additional studies in other nearby conservation areas with dry forests to establish conservation corridors to promote gene flow between forest patches.

Finally, the great diversity of small mammals of the SDTF of the Huallaga river basin, the new records, the biogeographic importance of dry ecosystems, and the Huallaga River as a barrier for dispersion of small, mainly terrestrial, mammal species invite further research in this area. Additional research may help to better understand the natural history, population dynamics, and dispersal patterns of small mammals in a forest characterized by high seasonality. Conservation efforts should address the effect of deforestation and fragmentation and propose a conservation plan and urgent decisions to maintain well-preserved relicts or patches of forests.

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Authors’ Contributions

DR designed the research, collected the specimens, analyzed the data, and drafted the article. VP contributed to the research design and critically reviewed the draft.

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Appendix

Table A1. Captured specimens in the SDTF of the Huallaga river basin in Valle del Biavo (VB), El Incaico (EI), El Quinillal (EQ), and Ojos de agua (OA), San Martín departament. Superscripts indicate: a) skulls or partial skeletons found in the collecting area, b) observed specimens.

Species	Localities				Total
	VB	EI	EQ	OA	
Order Didelphimorphia					
Didelphis marsupialis[a]	1		1	1	3
Marmosa constantiae	4				4
Marmosops bishopi		2		1	3
Marmosops noctivagus				1	1
Philander canus	1				1
Order Rodentia					
Hylaeamys perenensis	4	5		2	11
Nectomys apicalis				1	1
Proechimys brevicauda	16	6	1	11	34
Order Chiroptera					
Peropteryx macrotis				3	3
Saccopteryx bilineata[b]				6	6
Artibeus anderseni	8		2	8	18
Artibeus lituratus	1	2	8	34	45
Artibeus obscurus		1		1	2
Artibeus planirostris				10	10
Carollia benkeithi	14		3	2	19
Carollia brevicauda			1	3	4
Carollia perspicillata	13	3	17	46	79
Chiroderma villosum	3				3
Desmodus rotundus[b]				2	
Glossophaga soricina	2			1	3
Lonchorhina aurita			2		2
Micronycteris megalotis		1			1
Platyrrhinus incarum		3			3
Sturnira giannae			3		3
Uroderma bilobatum		2	2	6	10
Vampyriscus bidens		1			1
Pteronotus fuscus			1	2	3
Myotis keaysi			1		1
Myotis simus			1		1
Total	67	26	43	139	275

Table A2. List of species of small mammals occurring in the San Martín Department. Provinces: Bellavista (Be), El Dorado (Do), Huallaga (Hu), Lamas (La), Mariscal Cáceres (Ma), Moyobamba (Mo), Picota (Pi), Rioja (Ri), San Martín (Sn), Tocache (To). Conservation status: Near threatened (NT), Vulnerable (VU), Endangered (EN), Deficient data (DD). Records by provinces are supported by at least one reference, MUSM specimen, or records of this study.

	Species	D.S. 004-2014-MINAGRI	IUCN	Records by province	Source
ORDER DIDELPHIMORPHIA					
Family Didelphidae					
1	*Didelphis marsupialis**			Be, Mo, Pi, Ri, Sn	Osgood (1914), Thomas (1927), this study
2	*Didelphis pernigra**			Ma	MUSM 7463
3	*Caluromys lanatus**			La, Ri, Sn	Thomas (1927), MUSM 89
4	*Chironectes minimus**			Mo	Osgood (1914)
5	*Gracilinanus* cf. *aceramarcae*			Ma	Solari et al. (2001)
6	*Marmosa constantiae**			Be, Ma, Mo, Ri	Solari (2001), Voss et al. (2019), this study
7	*Marmosa lepida*			Mo	MUSM 47745
8	*Marmosa macrotarsus*			Be, Mo, Ri	Osgood (1913), Thomas (1927), Voss et al. (2019)
9	*Marmosa rutteri*			Ma, Mo, Ri	Patton et al. (1982), Voss et al. (2019)
10	*Marmosops bishopi*			Be, Do, Mo, Pi, Ri	Diaz-Nieto et al. (2011), Velazco and Patterson (2019), MUSM 35261, MUSM 35263, this study
11	*Marmosops caucae*			Be, Ma, Mo, Pi, Ri	Osgood (1914), Thomas (1927), Diaz-Nieto et al. (2016), Velazco and Patterson (2019), MUSM 7475
12	*Marmosops noctivagus*			Be, Ma, Mo, Ri	Thomas (1927), Diaz-Nieto et al. (2016), Velazco and Patterson (2019)
13	*Marmosops* 'Juruá'			Be	Diaz-Nieto et al. (2016)
14	*Metachirus myosurus**			Mo	Osgood (1914), Voss et al. (2019)

Species		D.S. 004-2014-MINAGRI	IUCN	Records by province	Source
15	*Monodelphis peruviana*			Mo	Osgood (1913): type locality
16	*Philander canus**			Be, Mo, Ri, Sn	Osgood (1914), Thomas (1927), Voss et al. (2018), this study
ORDER RODENTIA					
Family Cricetidae					
17	*Auliscomys pictus*			Ma	Leo and Romo (1992)
18	*Akodon aerosus*			Be, Mo, Ri	Osgood (1914), Thomas (1927), Velazco and Patterson (2019), this study
19	*Akodon orophilus*	VU		Ma, Mo, Ri	Leo and Romo (1992), Osgood (1913), Jiménez et al. (2013)
20	*Euryoryzomys macconnelli*			Mo	Velazco and Patterson (2019)
21	*Euryoryzomys nitidus*			Be, Mo, Ri	Osgood (1914), Thomas (1927), MUSM 46541
22	*Holochilus sciureus*			Mo, Ri	Thomas (1927), Gonçalves et al. (2015), Velazco and Patterson (2019)
23	*Hylaeamys perenensis*			Be, Do, Mo, Pi, Ri	Velazco and Patterson (2019), MUSM 35312, this study
24	*Hylaeamys yunganus*			Ma, Mo, Ri	Velazco and Patterson (2019), MUSM 24393, MUSM 39278
25	*Microryzomys altissimus*			Ma	MUSM 7919
26	*Microryzomys minutus*			Ma	Leo and Romo (1992)
27	*Neacomys minutus*			Mo	MUSM 35328
28	*Neacomys spinosus*			Ma, Mo, Ri	Osgood (1914), Leo and Romo (1992), Hurtado and Pacheco (2017)
29	*Nectomys apicalis*			Be, Pi, Ri, Sn	Thomas (1927), Chiquito and Percequillo (2019), MUSM, this study
30	*Nectomys rattus*			Ri	Velazco and Patterson (2019)
31	*Nephelomys* sp. nov.			Ma	Leo and Romo (1992), Ruelas et al. (in rev.)
32	*Oecomys bicolor*			Ma, Mo, Ri, To	Osgood (1914), Carleton and Musser (2015), Velazco and Patterson (2019), MUSM 43641
33	*Oecomys roberti*			Ma, To	MUSM 43642, MUSM 2393
34	*Oecomys superans*			Ri	Carleton and Musser (2015)
35	*Oecomys trinitatis*			Mo, Ri	Thomas (1924), Thomas (1927)
36	*Oligoryzomys destructor*			Mo, Ri	Osgood (1914), Thomas (1927), Velazco and Patterson (2019)
37	*Oligoryzomys microtis*			Ma, Mo, Ri	Velazco and Patterson (2019), MUSM 43643
38	*Rhipidomys modicus*			Mo, Ri	Thomas (1926a): Type locality, Tribe (2015)
39	*Thomasomys apeco*	VU	VU	Ma	Leo and Gardner (1993)
40	*Thomasomys aureus*			Ma	Leo and Romo (1992)
41	*Thomasomys eleusis*	VU	VU	Ma	MUSM 7974
42	*Thomasomys incanus*	VU		Ma	Leo and Romo (1992), Pacheco (2015)
43	*Thomasomys kalinowskii*	VU		Ma	MUSM 43652
44	*Thomasomys macrotis*	VU	VU	Ma	Gardner and Romo (1993)
45	*Thomasomys notatus*			Ma	Leo and Romo (1992), Pacheco (2015)
46	*Thomasomys taczanowskii*	NT		Ma, To	Leo and Romo (1992)
47	*Thomasomys* sp.			Ma	Leo and Romo (1992)
Family Echimyidae					
48	*Echimys saturnus*			Ma	MUSM 7888
49	*Mesomys hispidus*			Be, Ri	Thomas (1927), MUSM 46586
50	*Mesomys leniceps*	EN	DD	Ri	Thomas (1926b)
51	*Proechimys brevicauda*			Be, Pi, To	MUSM 2610, this study
52	*Proechimys simonsi*			Ri	Thomas (1926b)
ORDER CHIROPTERA					
Family Emballonuridae					
53	*Peropteryx kappleri*			Ri	Velazco and Patterson (2019), MUSM
54	*Peropteryx macrotis*			Pi, Ri,	MUSM 50701, this study
55	*Rhynchonycteris naso*			To	MUSM 1088
56	*Saccopteryx bilineata*			Pi	This study
Family Molossidae					
57	*Cynomops planirostris*			Sn	Solari et al. (1999)
58	*Eumops auripendulus*			Ma	Allen (1900)
59	*Eumops perotis*			La, Pi, Sn	Acha and Zapatel (1957)
60	*Molossus molossus*			Mo, Sn, To	Osgood (1914), MUSM 1319, MUSM 3004
61	*Molossus rufus*				Acha and Zapatel (1957)
62	*Tadarida brasiliensis*			Pi, Sn, To	Tuttle (1970), Acha and Zapatel (1957)
Family Mormoopidae					
63	*Pteronotus fuscus*			Be, Pi	Ruelas and Soria (in press.)
64	*Pteronotus gymnonotus*			Mo	MUSM 35098
Family Noctilionidae					
65	*Noctilio albiventris*			Ma	Koopman (1978)
Family Phyllostomidae					
66	*Anoura aequatoris*			Ma	MUSM 7214
67	*Anoura caudifer*			Ma, Mo	Solari et al. (2001), Velazco and Patterson (2019)

	Species	D.S. 004-2014-MINAGRI	IUCN	Records by province	Source
68	*Anoura fistulata*			Ma	Pacheco et al. (2009)
69	*Anoura* cf. *geoffroyi*			La, Ma, Mo, Sn	Acha and Zapatel (1957), Solari et al. (2001), Velazco and Patterson (2019)
70	*Anoura peruana*			Mo	MUSM 39114
71	*Artibeus anderseni*			Be, Mo, Pi, Ri, Sn	Velazco and Patterson (2019), MUSM 269, MUSM 35107, this study
72	*Artibeus concolor*			Ri	MUSM 35110
73	*Artibeus glaucus*			Ma, Mo, Ri	Velazco and Patterson (2019), MUSM 43585
74	*Artibeus gnomus*			Mo, Ri	MUSM 35117, MUSM 35115
75	*Artibeus lituratus*			Be, Mo, Pi, Ri, Sn	Thomas (1927), Velazco and Patterson (2019), MUSM 287, this study
76	*Artibeus obscurus*			Be, Do, Mo, Pi, Ri, Sn	Marques-Aguiar (2008), this study
77	*Artibeus planirostris*			Mo, Pi, Ri	Thomas (1927), Marques-Aguiar (2008), Velazco and Patterson (2019), this study
78	*Carollia benkeithi*			Be, Mo, Pi, Ri, Sn	Ruelas and Lopez (2018), Velazco and Patterson (2019), this study
79	*Carollia brevicauda*			Be, Ma, Mo, Pi, Ri, Sn	Solari et al. (2001), Ruelas (2017), Ruelas and Lopez (2018), Velazco and Patterson (2019), this study
80	*Carollia perspicillata*			Be, La, Ma, Mo, Pi, Ri, Sn	Thomas (1927), Ruelas (2017), Ruelas and Lopez (2018)
81	*Carollia* sp.			Ri	Velazco and Patterson (2019)
82	*Chiroderma trinitatum*			Mo	Velazco and Patterson (2019)
83	*Chiroderma villosum*			Be, Ma, Ri	Thomas (1927), MUSM 1642, this study
84	*Chrotopterus auritus*			Do, Ri	MUSM 35186, MUSM 50712
85	*Desmodus rotundus*			Ma, Mo, Pi, Ri	Thomas (1927), Velazco and Patterson (2019), MUSM 43587, this study
86	*Diphylla ecaudata*			Ri	Thomas (1927), Velazco and Patterson (2019)
87	*Enchisthenes hartii*			Mo, Sn	MUSM 45796
88	*Gardnerycteris crenulatum*			Ri	Thomas (1927)
89	*Glossophaga commissarisi*			Mo	MUSM 35188
90	*Glossophaga soricina*			Be, La, Ma, Mo, Pi, Ri, Sn	Osgood (1914), Acha and Zapatel (1957), Koopman (1978), Velazco and Patterson (2019), MUSM 35189, this study
91	*Glyphonycteris daviesi*			Do	MUSM 35198
92	*Glyphonycteris sylvestris*			Ri	MUSM 50713
93	*Lionycteris spurrelli*			Ri	Koopman (1978), Velazco and Patterson (2019)
94	*Lonchorhina aurita*			Be, Mo, Ri	This study
95	*Lonchophylla handleyi*			Sn	Velazco and Patterson (2019)
96	*Lophostoma silvicola*			Mo, Ri	Velazco and Patterson (2019), MUSM 35199
97	*Mesophylla macconnelli*			Mo	Velazco and Patterson (2019)
98	*Micronycteris megalotis*			Be, Ma, Mo	Solari et al. (2001), MUSM 35201, this study
99	*Phyllostomus discolor*			Mo, Ri	MUSM 35207, MUSM 35208
100	*Phyllostomus elongatus*			Ma	MUSM 1154
101	*Phyllostomus hastatus*			Mo, Pi, Ri, Sn	Acha and Zapatel (1957), MUSM 39777, MUSM 50657
102	*Platyrrhinus brachycephalus*			Mo	This study
103	*Platyrrhinus dorsalis*			Hu, Ma	Velazco and Solari (2003)
104	*Platyrrhinus ismaeli*			Hu, Ma	Velazco (2005)
105	*Platyrrhinus incarum*			Be, Mo	Velazco and Patterson (2019), this study
106	*Platyrrhinus infuscus*			Mo, Ri	Velazco and Patterson (2019)
107	*Platyrrhinus umbratus*			Hu, Ma	Velazco (2005)
108	*Rhinophylla pumilio*			Mo, Ri, To	Thomas (1927), Velazco and Patterson (2019), MUSM 267
109	*Sturnira aratathomasi*	DD		Ma	Solari et al. (2001), Gardner (2008)
110	*Sturnira bidens*			Ma, Mo	Solari et al. (2001), MUSM 35224
111	*Sturnira erythromos*			Ma	Solari et al. (2001)
112	*Sturnira giannae*			Be, Mo, Ri	Velazco and Patterson (2019), MUSM 35229, this study
113	*Sturnira magna*			Mo	MUSM 47739
114	*Sturnira oporaphilum*			Ma, Mo	Velazco and Patterson (2019), MUSM 24369
115	*Sturnira tildae*			Ma, Mo	Velazco and Patterson (2019), MUSM 24381
116	*Trachops cirrhosus*			Ri	MUSM 35235
117	*Uroderma bilobatum*			Be, Ma, Mo, Pi, Ri, Sn	Thomas (1927), Koopman (1978), Velazco and Patterson (2019), MUSM 1019,MUSM 35237, this study
118	*Vampyressa melissa*	VU	VU	Ri	Thomas (1926a): type locality
119	*Vampyressa thyone*			Ma, Mo, Ri	Velazco and Patterson (2019), MUSM 24382, MUSM 35244
120	*Vampyriscus bidens*			Be	This study
Family Thyropteridae					
121	*Thyroptera tricolor*			Mo, Ri	Velazco and Patterson (2019), MUSM 35245
Family Vespertilionidae					
122	*Eptesicus andinus*			Ma	Handley and Gardner (2008)
123	*Eptesicus brasiliensis*			Ma, Mo, Sn	Solari et al. (2001), MUSM 12747, MUSM 35246
124	*Histiotus montanus*			Ma	Solari et al. (2001), MUSM 7259

Species		D.S. 004-2014-MINAGRI	IUCN	Records by province	Source
125	*Lasiurus blossevillii*			Ma	Solari et al. (2001)
126	*Myotis caucensis*			Mo	Velazco and Patterson (2019)
127	*Myotis keaysi*			Be, Ma, Ri,	Solari et al. (2001), MUSM 35248, this study
128	*Myotis nigricans*			Mo, Ri, Sn, To	Osgood (1914), LaVal (1973), MUSM 903, MUSM 904
129	*Myotis oxyotus*			La, Ma, Ri	Acha and Zapatel (1957), Koopman (1978), Solari et al. (2001)
130	*Myotis riparius*			Mo, Ri	Velazco and Patterson (2019), MUSM 35247
131	*Myotis simus*		DD	Be	This study

* Medium-sized mammals.

Table A3. Diversity of small mammals in the dry forests of Peru: Seasonally Dry Tropical Forests of the Huallaga river basin (SDTF—H; this study), Seasonally Inter—Andean Dry Forest of Apurímac (SIDF—A; Pacheco and Hocking 2006; Pacheco et al. 2007b), and Pacific Equatorial Dry Forest (PEDF; Pacheco et al. 2007a; Novoa et al. 2011).

Species	SDTF-H	SIDF-A	PEDF
	300–600 m a.s.l.	1800 m a.s.l.	0–1000 m a.s.l.
ORDER DIDELPHIMORPHIA			
Family Didelphidae			
*Didelphis marsupialis**	x		x
*Marmosa constantiae**	x		
Marmosa robinsoni			x
Marmosops bishopi	x		
Marmosops noctivagus	x		
*Philander canus**	x		
ORDER RODENTIA			
Family Cricetidae			
Aegialomys baroni			x
Calomys sorellus		x	
Hylaeamys perenensis	x		
Nectomys apicalis	x		
Phyllotis amicus			x
Phyllotis gerbillus			x
Rhipidomys leucodactylus			x
Sigmodon peruanus			x
Family Muridae			
Rattus rattus		x	
Family Echimyidae			
Proechimys brevicauda	x		
Proechimys decumanus			x
ORDER CHIROPTERA			
Family Emballonuridae			
Peropteryx macrotis	x		
Saccopteryx bilineata	x		
Family Furipteridae			
Amorphochilus schnablii			x
Family Molossidae			
Eumops auripendulus			x
Eumops nanus			x
Eumops wilsoni			x
Molossus molossus			x
Mormopterus kalinowskii			x
Nyctinomops aurispinosus			x
Nyctinomops laticaudatus			x
Promops davisoni			x
Tadarida brasiliensis			x
Tomopeas ravus			x
Family Mormoopidae			
Mormoops megalophylla			x
Pteronotus davyi			x
Pteronotus fuscus	x		
Family Noctilionidae			
Noctilio leporinus			x
Family Phyllostomidae			
Artibeus anderseni	x		
Artibeus fraterculus			x
Artibeus lituratus	x		
Artibeus obscurus	x		
Artibeus planirostris	x	x	
Carollia benkeithi	x		
Carollia brevicauda	x		x
Carollia perspicillata	x		x
Chiroderma villosum	x		
Chrotopterus auritus			x
Desmodus rotundus	x	x	x
Diaemus youngi			x
Enchisthenes hartii			x
Gardnerycteris keenani			x
Glossophaga soricina	x		x
Lonchophylla hesperia			x
Lonchorhina aurita	x		
Lophostoma occidentalis			x
Micronycteris megalotis	x		x
Phylloderma stenops			x
Phyllostomus discolor			x
Phyllostomus hastatus			x
Platyrrhinus incarum	x		
Sturnira aratathomasi		x	
Sturnira bakeri			x
Sturnira giannae	x		
Sturnira luisi			x
Uroderma bilobatum	x		
Vampyriscus bidens	x		
Vampyrum spectrum			x
Family Thyropteridae			
Thyroptera discifera		x	
Family Vespertilionidae			
Eptesicus innoxius			x
Lasiurus blossevillii			x
Myotis albescens			x
Myotis atacamensis			x
Myotis keaysi	x		x
Myotis nigricans			x
Myotis riparius			x
Myotis simus	x		
Total species	29	6	47

* Medium-sized mammals